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ESTIMATING MUSKRAT POPULATIONS BY HOUSE COUNTS

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ESTIMATING MUSKRAT POPULATIONS BY HOUSE COUNTS [1]

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INTRODUCTION

In general muskrats are nocturnal in their habits. They are most active from dusk to about eleven at night and again in the early hours of the morning. The extent of their diurnal activity seems to vary considerably with different races and geographic location. This fact must be taken into consideration in any trapping operation. Tidewater muskrats are said to feed most actively on flood-tide and to "hole up" in their nests during ebb-tide. The time and height of tides are strongly affected, however, by the force and direction of the wind and also by the depth and contour of the shore and topography. In both the Delaware and Chesapeake Bay areas a northwest wind favors a low tide, and one from the southwest a high tide. Muskrats of the coastal race *macrodon* and the Louisiana *rivalicius* are extremely wary and secluded in their habits and are only occasionally seen during bright sunlight; in fact, a trapper may tramp the marsh days before actually seeing an active animal and trap lines are generally run once daily. On the other hand, muskrats of the Common Eastern _zibethicus_ race and the Great Plains _cinnamominus_ show considerable diurnal activity and trap sets may be visited several times a day to good advantage.

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[1] This paper was delivered at the 13th North American Wildlife Conference, St. Louis, Missouri, March 9, 1948.

For survival, muskrats depend largely on concealment and a considerable part of their existence is spent in underground tunnels and burrows, inside of their nests and feeding shelters, in swimming, and in digging loose and gnawing on the subterranean roots of various aquatic marsh or swamp plants. For this reason their presence on an area is detected by evidence of their activity rather than on actual observation of the animals themselves. Muskrat "signs" may take the form of narrow channels or runs leading through the marsh to and from nesting sites and nearby feeding grounds, air bubbles under ice, bank burrows and tunnels, plant cuttings, roiled or muddy water in "leads", tracks, defecating posts, plunge holes, and the large mound-like houses and smaller feeding huts.

ESTIMATING MUSKRAT POPULATION

The number of individuals of any species of animal on a given area is continually changing. As pointed out by Bell et al (1947) 1/ "So complicated is the taking of mammal censuses and so varying the habits of the different species that it is necessary to employ a different method for almost every group". In the case of the muskrat, however, estimates can be fairly accurately and easily made in late fall on the more open types of habitat by annual counts of the conspicuous, haycock-shaped houses or "beds" present, used in conjunction with the number of bank leads or den burrows. On any particular marsh an increase or decrease in the number of houses signifies the relative change in the number of muskrats from year to year.

House counts are now being more generally recognized to be an excellent management tool for annually estimating the number of muskrats on an area, determining population trends, assignment of trappers and the extent of acreage to be allotted each, and regulation of the permissible "take" by quota limits. These counts also offer an excellent opportunity to make observations and notes as to the amount of muskrat "signs" and activity present, the type of vegetation and cover, possible changes in the abundance of muskrat food available, and the extent of predation and disease. The writer (1947) demonstrated through annual house counts and accompanying catch records over a long period that cyclic fluctuations cannot be attributed to mere trapping variation.

THE ANNUAL HOUSE COUNT AS AN INDEX TO MUSKRAT POPULATION

The reliability of muskrat house counts as a census method is sometimes questioned. This will depend, however, on the season of the year and conditions present at the time the census is undertaken and to an even larger extent on the marsh experience and ability of the counters to differentiate between old, unoccupied, "dead" houses and the newly constructed or freshly patched-up, inhabited "live" houses; between actual nesting or dwelling houses and feeding huts or shelters.

1/ Publications referred to parenthetically by date are listed in the Literature Cited, Page 12.

Shortly after being trapped out or deserted, muskrat houses take on an old, straw-colored, fallen-in appearance. In some of the more northern sections spring freshets or floods bring about the total disintegration and washing away of the winter houses and in that case practically all of the early spring litters are of necessity produced in bank dens. Under "still-water" conditions, however, such old, unoccupied houses may remain for many months, but can usually be readily distinguished by an occupying growth of Polygonum, Cyperus, Fern and Pluchea that takes over rather quickly. Sterns, MacCreary and Daigh (1940) have shown that many of these old house foundations or sites have been in continuous use for several years. On coastal ebb-and-flow marshes uninhabited houses gradually fall to pieces and are "flushed out" by strong tidal action. The possibility that mites and disease carry over in unused houses for months cannot be easily discounted.

To be most useful as a basis for planning the trapping operation for the year, the annual house count should be undertaken as early in the fall as is feasible. House construction activity cannot be judged as completed until after chilly nights and a real killing frost have arrived. The latter is needed in order to flatten down the rank vegetation and make for better visibility. Aldous (1947) states that the earliest possible date for counting houses under South Dakota conditions would be about October 20 and that the count should not be taken earlier than October 25.

Under Atlantic coastal conditions muskrats usually start to "push-up" houses or beds with the arrival of the first high tides or rise in water in early September. Actual house construction and fresh "patching-up" can carry through into the first week in November. Theoretically, at this time the maximum surviving muskrat population of the year's production is present, representing the nearest true basis for trapping estimates.

TYPES OF STRUCTURES INVOLVED

In order to make an accurate population estimate it is essential that one know certain fundamental habits of the animal and the various kinds of structures and "signs"involved. In the case of the muskrat these structures are variously known in different sections of the country as lodges, beds, and huts, but house is of more general and wide-spread usage and seems preferable. The term "live" or "inhabited" is used by the trapper to indicate houses or structures of any type that are actually occupied or in use at the time by active muskrats. This is in contrast to the use of "dead" to designate houses or feeding shelters from which the occupants have disappeared through being "trapped-out" or by possible disease, predation, or migration. Newly constructed, well-built, large houses and old ones that show fresh patching-up, repair work or chinking with mud, usually denote occupancy. An unfailing index of habitation is the evidence of fresh cutting and feeding, muddy or roiled water in the "leads", and cleaned out tunnels and plunge holes. (Plate 1, upper.)

Considerable confusion exists in regard to just what constitutes a muskrat house, a feeding hut or shelter, and a push-up or breather. It seems highly desirable, therefore, to briefly define and discuss these

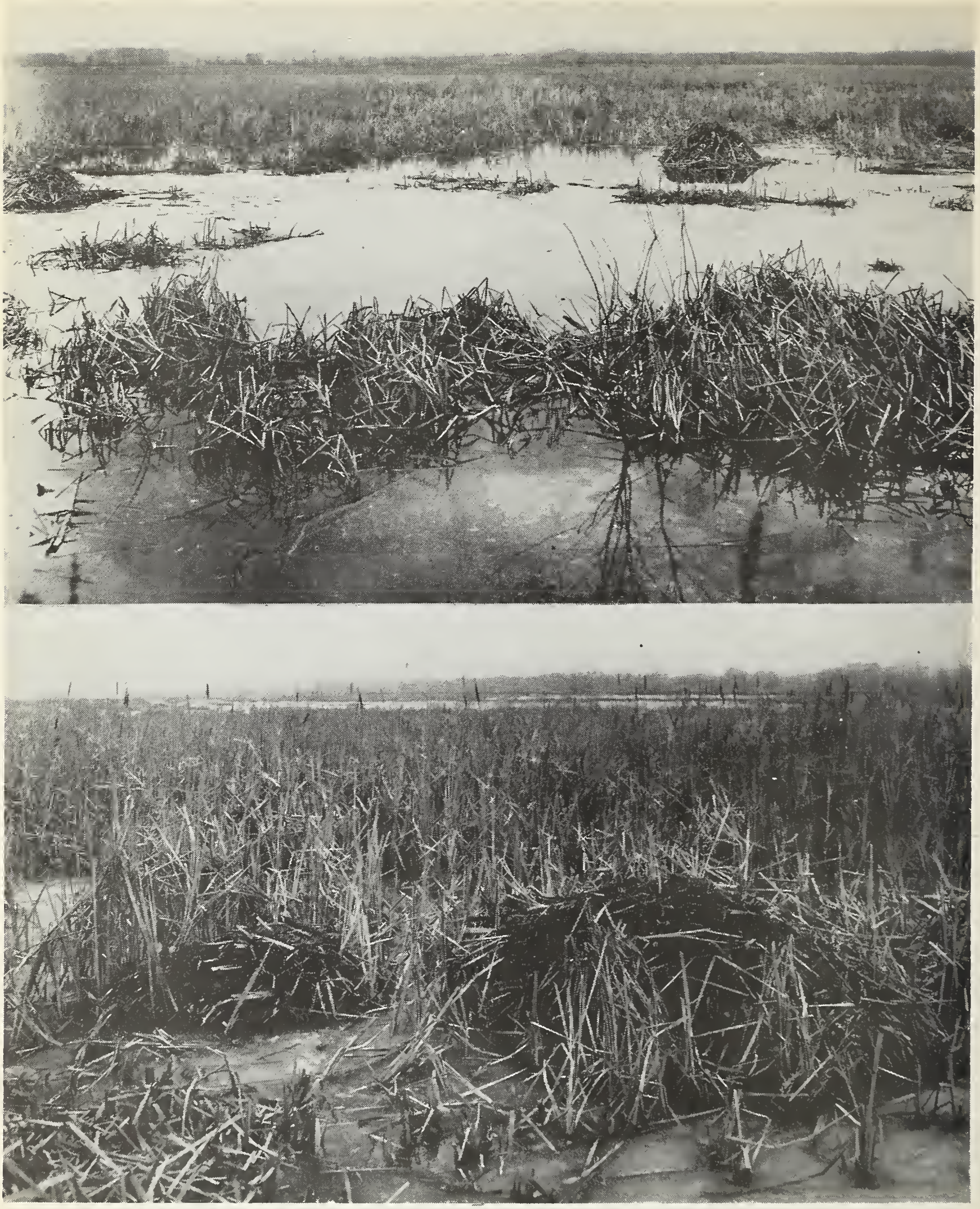

Plate 1

Upper. Large nesting or dwelling house with four surrounding feeding huts in cattail and mixed burreed fresh-water marsh, Montezuma National Wildlife Refuge, New York, March 16, 1944.

Lower. Close-up view of inhabited dwelling house (6 feet 4 inches basal circumference) and adjacent feeding hut (3 feet 6 inches greatest diameter, 16 inches height, and 9 feet 8 inches basal circumference) in same marsh.

terms and of other types of structures that are also involved in making accurate estimates of muskrat populations.

Nesting or Dwelling Houses

The nesting house or lodge can usually be quickly distinguished by its larger size, type of construction and "live" appearance. It is generally much taller, more or less elliptical in outline, with the top generally rather lop-sided or peaked and often showing signs of addition, patching or repair, and chinking with mud as the necessity arises during the winter. There is considerable variation in the size and height, depending on the kind and amount of food present, the severity of the season, fluctuating water levels, and perhaps the number and individuality of the inhabitants. The height may vary from 16 inches to 4 feet and the thickness of the walls from 4 to 12 inches. They are to be found in water varying from 6 to 35 inches. A representative large house in Central New York measured 34 inches in height above the ice level, had a basal circumference of 20 feet 10 inches and the greatest diameter was 7 feet; the largest house examined was only 25 inches in height but with a basal circumference of 28 feet 10 inches and greatest diameter of 10 feet 5 inches, constructed entirely of blue flag cattail. The largest house ever studied by the writer in Maryland measured 22 feet 7 inches in greatest length by 10 feet in width. It was rather flattened in general appearance being only 2 feet 8 inches high above the water level and contained two main nesting chambers. (Plate 1, lower.)

When a "live" nesting house is opened during the fall or winter a dry, well-lined nest or chamber is generally found well forward and above the water level, with several different "runs" down to plunge holes leading into the water for entrance and escape. An experienced trapper generally has little difficulty in distinguishing between the true winter nesting or lodging house and the surrounding "feeders". In a small percentage of cases the external characteristics are not so clear cut and call for good judgment or a few minutes of close internal examination.

Feeding Huts or Shelters

The feeding hut, or "feeder" as it is commonly called by the trapper, cannot be considered an inhabited house in the true sense of the word but is a place rather where the muskart can at intervals bring in and consume food on a small feeding platform without molestation from its enemies and protected from the elements. Under the constant frozen conditions in the more northern states the feeding hut becomes a necessity for needed rest and ready access to oxygen space.

It can generally be easily distinguished from the nesting house by its decidedly smaller size, roughly circular outline, usual low height of only 12 to 16 inches above the ice or water level, and the more rounded and uniform construction. When opened, a small central feeding platform, containing the remains of bits of roots, cattail shoots, coontail, etc., is usually found just above the water line. There are always several runs leading in and out of this beneath the ice or water level. (Plate 2, upper.)

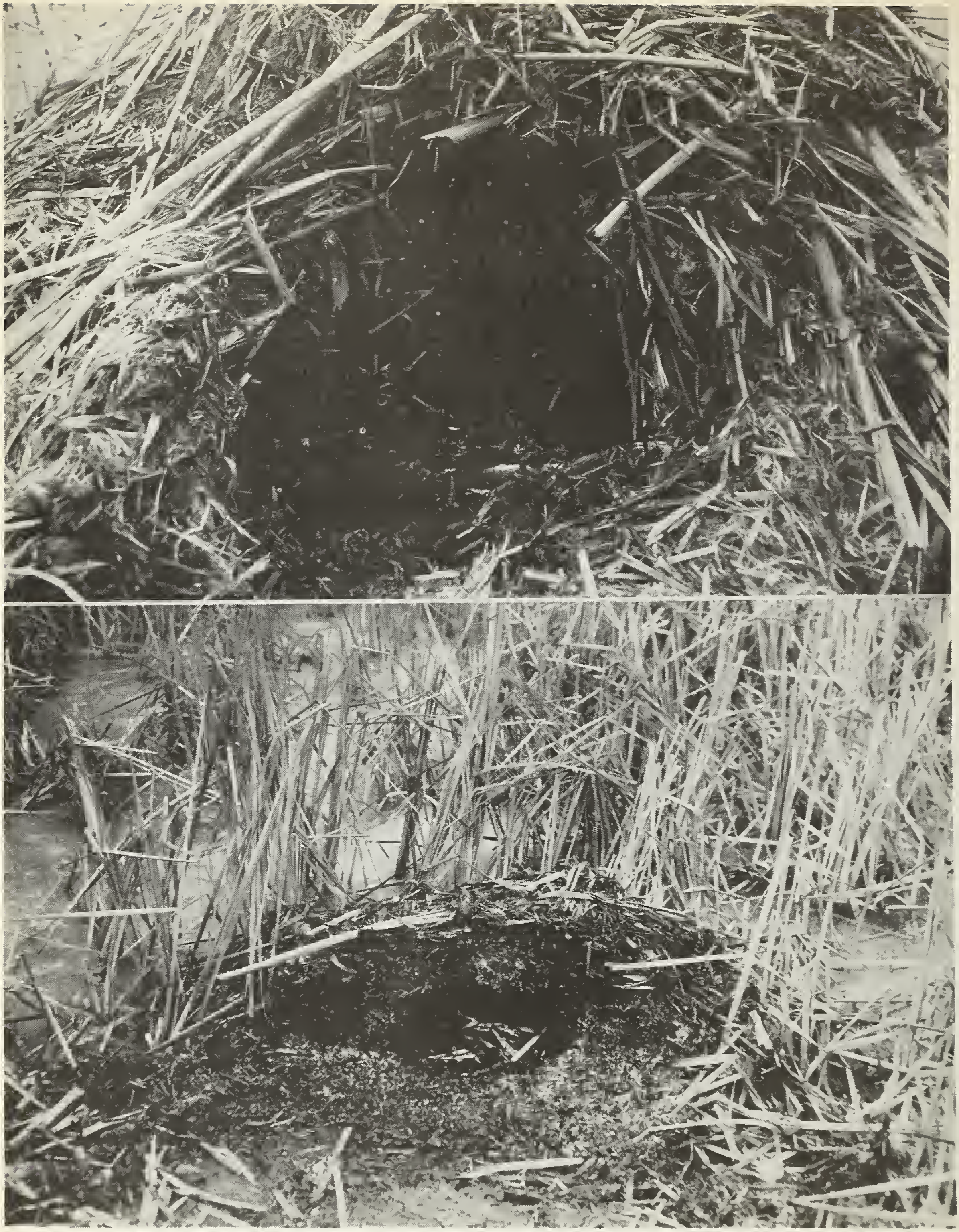

Plate 2

Upper. Large dwelling house opened to show the two plunge holes into water and run leading up to dry nest at higher level.

Lower. Feeding hut with front third removed to show the feeding platform and remains of winter shoots of Typha angustifolia var. elongata, Montezuma National Wildlife Refuge, New York.

Usually the large nesting house is conveniently surrounded, at varying distances from suitable feeding grounds, with one or more feeding huts. A careful check, made in the central New York marsh in 1940, showed 140 feeding shelters to 52 nesting houses, a ratio of 2.69, with as high as four in some cases. In contrast, the count on a poorer, more flooded section showed only a single feeder per nesting house. The number and sturdiness of these will vary with the necessity. On our Atlantic coastal marshes, where climatic conditions are less severe the tightly constructed feeding hut is replaced by a rather flimsily and hurriedly "thrown-up" feeding shelter. During the summer and farther south only open feeding platforms or stations may be needed. (Plate 2, lower.)

Push-Up or Breather

The term "push-up" seems to have a good many different meanings in various sections of the country. In Maryland, for example, with the arrival of high water in early fall, muskrats are said to "push-up" or "shove-up" houses. In the warmer climate of that section, however, nothing has been noted that is comparable to what Cartwright (1946) and others define as a "push-up" or breather in the frozen marshes of the northern states. Such push-ups appear to be largely confined to the deeper channels, river edge, and lakes and are almost invariably coupled with snow. Push-ups are started by the muskrats cutting a 4 to 5 inch hole through the ice and pushing up through this a 12 to 18 inch pile of fine fibrous roots, water weed or other submergent vegetation. This is in marked contrast to the more bulky upper parts of cattail, etc., ordinarily used in the construction of the feeding shelter. The material rests on top of the ice, in a lumpy or somewhat ball formation, and the muskrats make an inside cavity at the ice level which serves as a resting place and breather. In severe weather these may also be used as feeding stations. Just as soon as ice forms on the channels in late fall holes are kept open and the construction of push-ups is started. These small structures easily escape detection in the snow but become readily observed after this disappears. They are only of a temporary nature and when the ice melts they have no support and immediately collapse. (Plate 3, upper.)

Bank Leads and Den Burrows

Between different marshes there are likely to be differences in amount of use made of houses. Only a part of the muskrat total in any section of the country actually inhabit open marshes and construct houses. Along wood edges, stream banks, shores of lakes and ponds, levees, dikes, and drainage ditches fewer houses are built and most of the muskrats live in burrows or dens. This fact must be kept in mind when any attempt is made to convert house counts into number of muskrats present on an area.

Where there are good high firm banks to burrow in muskrats seem to prefer these to houses. The latter are used more generally where the banks are so low that the dens or upper chambers are liable to frequent flooding. Entrances to these burrows are usually under water most of the year except in cases of extreme drought or fluctuating water levels. Clay banks are an excellent medium to burrow in while light, sandy ones cave in frequently and discourage use by muskrats. The system of tunnels may be exceedingly complex and some of these may be of many years' standing.

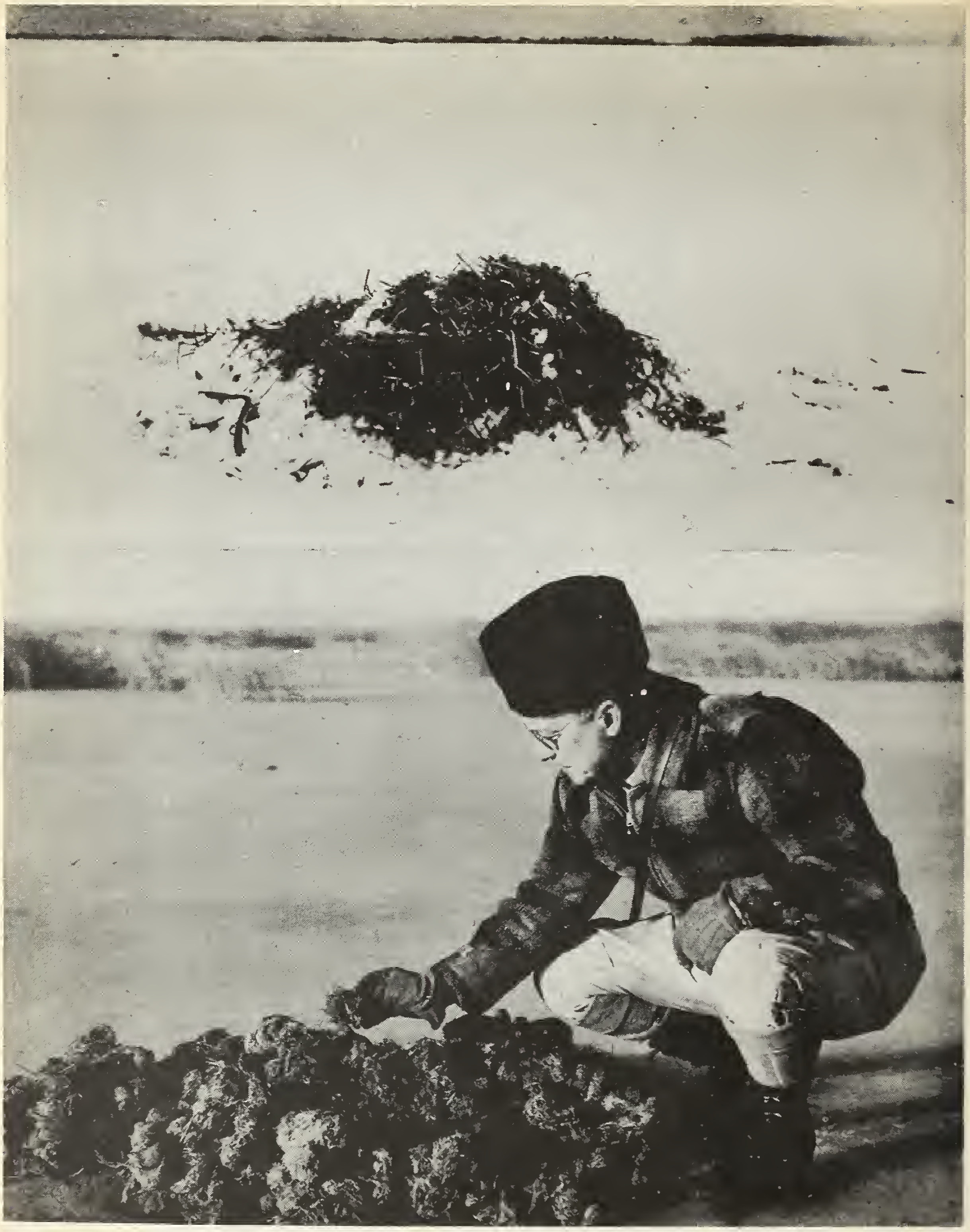

Plate 3

Upper. A muskrat "push-up" or breather partially covered with snow, on a frozen Bad River Marsh slough, Odenah, Wisconsin, April 12, 1944 (Courtesy of Laurits W. Drefting, Great Lakes Indian Agency).

Lower. A typical "push-up" on ice covered Jack Fish Lake, Big Cord Grass Marsh, Monitoba Province, Canada (Courtesy of B. W. Cartwright, Ducks Unlimited (Canada).

The, often unsuspected, tunnels vary considerably in diameter and length. They generally lead back into a main burrow and then upward where this enlarges into one or more large nesting chambers well above the water level. Some burrows have no offshoots and may end abruptly into a roughly semicircular chamber. The larger burrows may have small, well-hidden, "surface openings" that are usually kept loosely plugged, with vegetation. Undoubtedly these serve as air vents as circulation of air is extremely important in this damp underground system in order to maintain proper living and nesting conditions. Warwick (1940) employed an iron probing bar to good advantage in locating den burrows. The distance under water of the burrow entrance or "pipe leads" varies greatly, often occurring at several different levels along river banks, as an adjustment to the frequent rise and fall of the water. (Plate 3, lower.)

Temporary and Semi-Permanent Retreats

Frequently muskrats find harbor or retreats in old fallen, hollow logs or stumps at the waters' edge, under piles of lodged debris, in overhanging banks held together by sod, root tangles and brush, and occasionally in discarded oil drums, barrels and boxes. Large, well-constructed houses or shelters are often encountered in some sections in thickets of scrub willow or similar vegetation.

As pointed out by Errington (1937), "individually, such retreats may be present one month and gone the next, but collectively they are doubtless of importance to existing muskrat populations". For all practical purposes, however, such habitations are seldom taken into consideration in an annual census.

CENSUS METHODS

Any method for censusing muskrats should be both simple and practical. It must portray trends in muskrat abundance and be sufficiently accurate for administrative use in setting legal open seasons and trapping unit quotas. The first two methods discussed represent sampling while the last two involve a more or less complete count of entire areas.

Transects

No completely satisfactory transect method of estimating muskrat populations has been devised to date. The difficulty of making such a census arises from having so many different and varied types of habitat, including the complication of "bank muskrats". On marshes with a rather uniform plant formation and house distribution transects may often be utilized to good advantage and are cheaper. To be accurate and most useful such transects should be permanently staked out, with the acreage involved accurately computed, in order to make yearly comparisons.

Counts From Roadside

Attempts by workers in several states to use this method of censusing muskrats have given unsatisfactory results. The excessive amount of driving involved and the inability of the observer to spot a considerable portion of the houses or to determine their actual character are important limiting factors. (Plate 4, upper.)

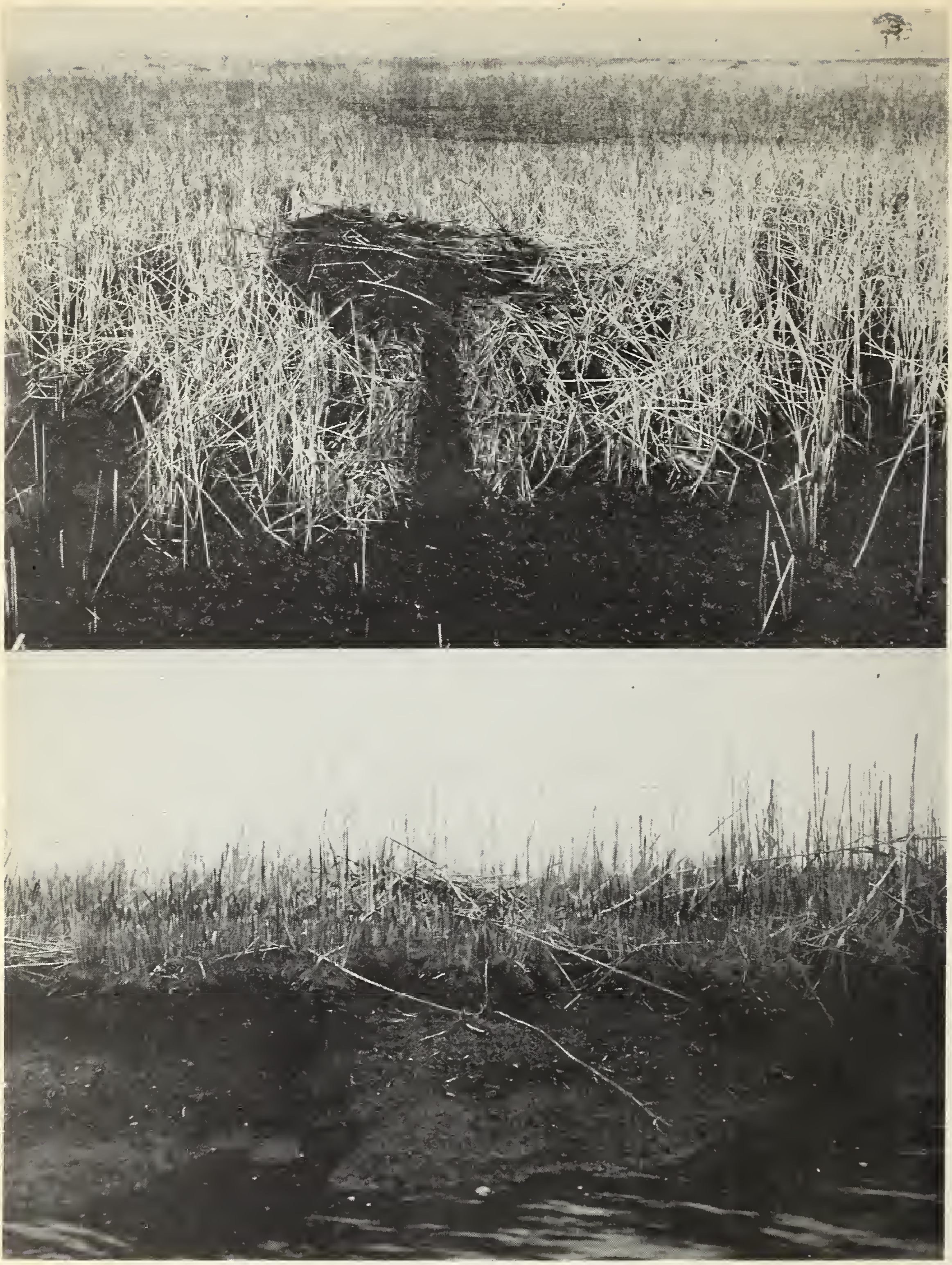

Plate 4

Upper. A nesting or dwelling house, showing mud runway up the side and fresh patching during a cold spell, Blackwater National Wildlife Refuge, Maryland, December 19, 1938.

Lower. Muskrat "pipe leads" along a Maryland river in wild reed, Spartina cynosuroindes, formation; taken at very low tide to show tunnel entrances at three different tide levels.

Ground Strip Counts

Unquestionably the most accurate house count and population estimate can be made from the ground, if sufficient time and personnel are available to cover an area adequately. Such a survey has been conducted annually on the Blackwater National Wildlife Refuge in tidewater Maryland since 1933 to the present and has served as a very satisfactory basis for trapping operations. In the early counts only the larger or so-called nesting houses were included. With the establishment of the U. S. Fur Animal Field Station on this refuge in the late fall in 1937, the annual house count has been continued by station personnel, using the "strip" method and employing the services of three men, boat equipment, and hand tally counters. This consisted of a total count of all "live" houses, listing nesting or dwelling houses and feeding shelters separately.

An accurate count of the various trapping "hunts" or units is dependent on these being well-delimited by natural boundaries and proper stakes or markers. Each day, prior to the working of the unit, a brief study should be made of the basic field map showing the topography and outline of the area. The knowledge of the location of each creek, pond, or gut is necessary to facilitate carrying out of the survey in the most effective and labor saving manner.

The crew is lined up at the most logical starting point and each man is placed at a certain distance apart. The customary strip or section to be covered by each counter is approximately 50 feet wide but this is determined largely by the type of cover present and its density. The object is to cover as much of the unit in each "strip" as is possible, the limiting factor being the distance that all muskrat houses and shelters can be clearly seen in the densest vegetation. The two men on the outer lines are responsible for guiding the crew. As the strip is followed down each man counts all houses between himself and the man on his inside (inside meaning toward the part of the unit that had already been counted). The first man on the inside always counts the houses between himself and the marks that have been made on the previous trip to designate or show the limit covered in making that strip. The counter on the outside is always responsible for properly marking the limits and the simple method of heaping up muskrat house material into a small tower on a large muskrat house can be employed. This temporary mound or tower is readily discernible at a considerable distance and has proved to be very useful. (Plate 4, lower.)

In counting muskrat houses the method has to be varied slightly where areas prove to be badly "eaten-out" or broken up by numerous ponds, creeks or guts. Good judgment in the selection of the best time to work each area is necessary as weather conditions and tides are important factors. It is necessary to arrange the survey so that at the end of the day the crew will find themselves reasonably near the starting point of the day's operations.

For comparative purpose units should be counted each year in the same rotation in so far as possible.

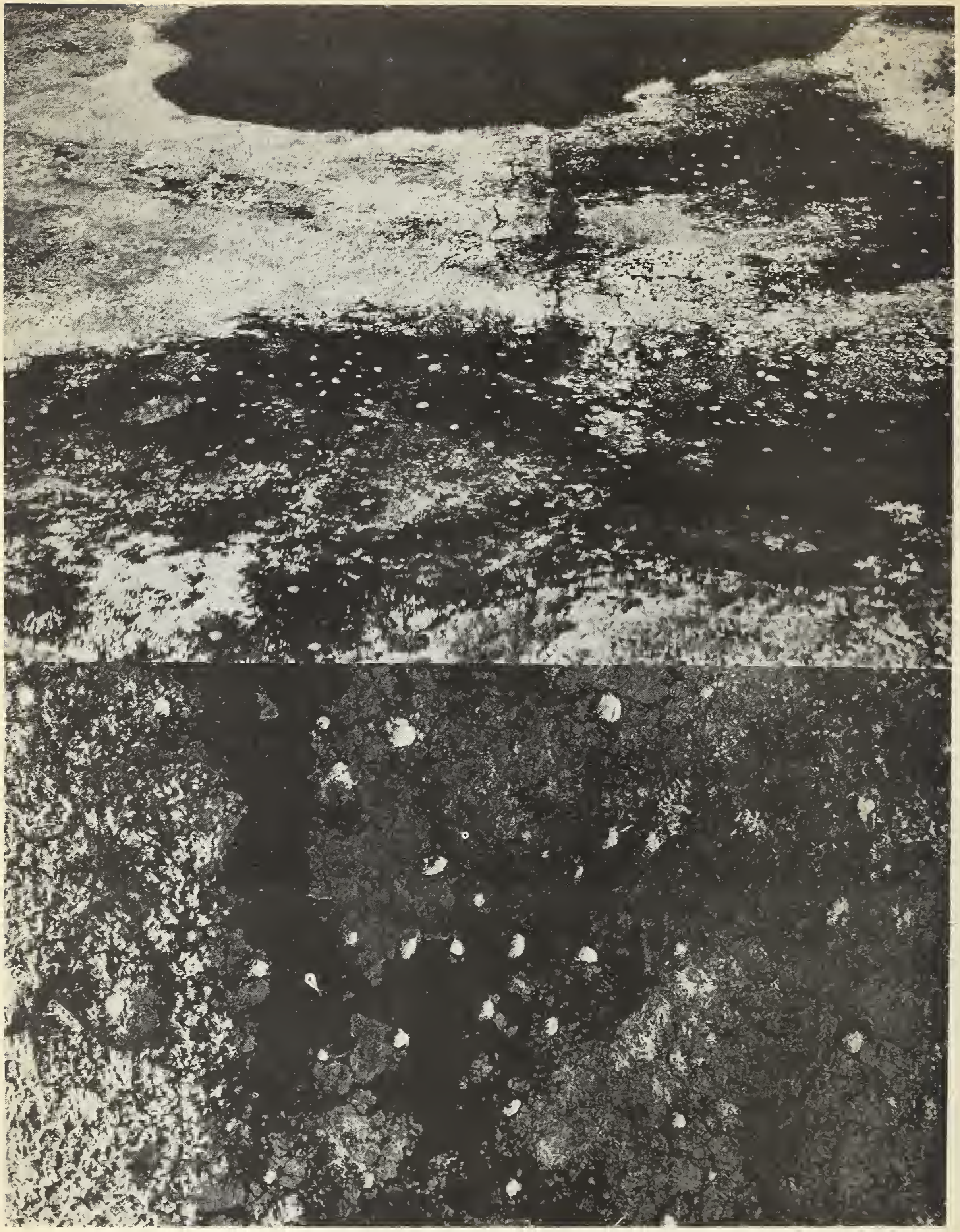

Plate 5

Upper. Aerial view covering approximately 15 acres of coastal marsh in North Carolina (Courtesy of Kenneth Wilson of the North Carolina Wildlife Resources Commission; taken from a dirigible by Lt. Haynes, U.S. Navy).

Lower. View of a 4 acre segment of the above.

Aerial Census

The need for a quicker and more economical census method than that of ground strip counting is apparent. Use of the airplane or helicopter for observation and possibly aerial photography may be the answer. Lay (1945) reported as promising the use of aerial observation in censusing muskrat houses on the Texas gulf coast but the best types of equipment and technique under varied conditions have yet to be worked out. An aerial observer can often count in a few hours what it may take a three man crew several days to cover on the ground.

The advantage of quicker coverage and possible savings in cost of an aerial census may, however, be more than offset by certain limitations not at first apparent. Costs must be figured on the total time that the pilot, crew, and flying equipment are tied up on a project rather than just the actual short productive flight period. Standardized, comparative data cannot be obtained if different observers and types of planes are employed each year and under varying weather conditions. For accurate counting of individual trapping units, the latter must be clearly set off by boundary markers easily visible from the air and the observers must be properly oriented.

Although the material used in the construction of the muskrat house tends to blend into the rather uniform fall straw color of the marsh vegetation, these houses can be distinguished from the air. Where the marsh immediately surrounding the house has been cleared of vegetation, the appearance of the house and water area remind one somewhat of a doughnut, the house comparing to the hole in the middle. On badly eaten stretches the houses stand out clearly but it is more difficult to spot the smaller ones in dense vegetation. With good visibility the larger houses may be discerned from altitudes as high as 800 to 1,000 feet, within a 3/4 mile radius. Lower level observation at 200 feet or less becomes necessary in order to accurately distinguish the houses under conditions of light scattered snowfall and where a very accurate count of individual, staked out trapping units is desired. In the more northern states counts can often be made to good advantage even when the marsh is blanketed with snow. In windswept areas, most of the snow is quickly blown away from the tops of the houses, making these stand out. Under the more moderate weather conditions prevailing in some sections, the warmth generated by the occupants of a "live" dwelling house is sufficient to melt most of the snow from the crown. Feeding huts, on the other hand, cannot be seen as they remain hidden by snow. Under conditions in the deep south where marsh areas are regularly burned early in the fall the straw-colored houses stand out distinctly against the charred, black background of burned vegetation. (Plate 5, upper.)

NORMAL RANGE AND MOVEMENTS

Various workers have shown through recapture of tagged animals that there is a marked tendancy for muskrats to remain quite close to their immediate home range under normal conditions. Errington & Errington (1937) first demonstrated in Iowa that the young-of-the-year tended to stay within familiar territory. Later, Errington (1944) reported recovery of several individuals that 561, 521 and 552 days after tagging had dispersed to about 2-1/4, 3 and 3-1/4 miles respectively.

Takos (1944) found that the tendency in Maine, even in the spring and summer, was to remain within a 25 foot radius of the tagging site and that less than 30 per cent were recaptured beyond a 100 foot radius. Aldous (1947) in South Dakota reported that only 15.2 per cent of animals, tagged in the summer and recaptured during the winter trapping season, had moved in excess of 31 rods; the greatest movement was only 200 rods or .62 miles.

Migratory movements occasioned by food depletion (eat-outs), deep freezing, or flooding and cyclic decline in population due to disease, predation or drought are all possibilities that should be taken into consideration in a survey. (Plate 5, lower.)

NUMBER OF ANIMALS PER HOUSE

During the fall and winter the parent muskrats and their last litter generally remain together through family ties, and for warmth and protection in the same dwelling house until the spring mating season arrives. Little is actually known as to how the survivors of the earlier litters have segregated by this time or have constructed houses of their own. The gregarious habit undoubtedly has an important bearing on the number of muskrats that may be present in a dwelling house in the fall and winter. Data assembled by the writer indicates that the inherent litter size capacity may vary considerably with the race. The number of rats per "live" dwelling house, therefore, will depend to a large extent on the average litter size of the race involved and the survival rate up to the time of the annual house count or fall survey.

Data, reported by various workers throughout a good portion of its range, indicate an average litter size of 6 for the Common Eastern muskrat, _Ondatra_ _z._ _zibethicus_. Smith (1938) gave an average of 4.4 for the Virginia or Coastal race _O._ _z._ _macrodon_, based on 10 sets of embryos obtained from Maryland trappers. In Louisiana, Arthur (1928) found an average of 3.85 for _O._ _z._ _rivalicius_ in 1,058 sets of embryos examined.

In addition to the small amount of information available on size of the litter in the various races at this time, there is also practically nothing known of the actual rate of survival of either adults or young. Dozier, Markley and Llewellyn (1948) have shown that the number of muskrats inhabiting a house, tends to remain approximately the same in years of both scarcity and abundance. Following house construction in the fall, however, outbreaks of disease have occasionally occurred and greatly reduced the population over widely scattered areas, thus upsetting possible catch estimates.

On certain units of the Blackwater Refuge in Maryland in the fall of both 1946 and 1947 numerous large dwelling houses, that had been counted as freshly constructed, "active" ones at that time, had assumed a deserted, straw-colored appearance by the first of January when trapping was started. Subsequent operations upheld the fact that something drastic had happened to the muskrat population after the houses had been built. As there was no evidence of any migration or serious predation at the time the most plausible explanation appeared to be that a particularly virulent form of disease had struck, even though few dead muskrats could be found when trapping was commenced.

CONVERSION FACTOR

The arbitrary figure of five per large house has been more or less generally accepted during recent years as a conversion factor for estimating muskrat populations. A more exact and satisfactory one could probably be derived if the survival rate were only known. Five muskrats per "live" dwelling house seems a very reasonable conversion figure for such races as zibethicus and cinnamoninus but probably represents an underestimation in normal years.

The experience of old time Maryland "giggers" give an excellent basis for the coastal macrodon. Some of these used to gig as many as 150 muskrats in a single afternoon, before such practice was outlawed. This consisted of slipping up quietly to a dwelling house and plunging a 5 to 7 pronged iron gig or fork into the nest, impaling the sleeping, cuddled-up muskrats in the same. The highest gigged from any one house was reported as 7 to 8 and all considered 4 to be a good average "take" per house.

The writer believes that the racial litter size should be first determined and this used as the best factor for converting number of "live" dwelling or nesting houses into estimated muskrat population, with due consideration given the question of bank muskrats. How many muskrats can or will be actually trapped will depend on the ability, energy, and equipment of the trapper, the extent of acreage assigned and quota set, and above all limiting climatic factors, such as snow and ice, heavy rainfall and fluctuations in water level, and in tidewater sections the prevailing winds and tide especially.

RELATION TO REGULATORY TRAPPING LAWS

Unless sufficient muskrats are trapped off to maintain a proper balance between the number of animals on a marsh and the carrying capacity of the same, severe "eat-outs" frequently occur that are ruinous to muskrat production. On the other hand most marsh lands, that have been open to indiscriminate, uncontrolled public trapping, have been almost completely trapped out.

Lay (1945) formulated a theory that, where nearly all muskrats on a given trapping unit live in houses, 2.5 animals per house can be harvested in Texas without jeopardizing the brood stock left for another season; that a catch of 2 per house is a conservative figure. Under tidewater Maryland conditions, 2 per "live" nesting house is considered good trapping and the average yield has been consistently much lower.

Regulations setting dates and length of the open season and methods of trapping permitted vary considerably in the different states. Trapping in and immediately adjacent to muskrat houses is prohibited in some. The proper interpretation of the term "house" therefore becomes a necessity. Intelligent management of marsh can be greatly hampered and proper harvesting of the annual muskrat crop made extremely difficult, under frozen conditions in the more northern states, if the feeding hut is placed in the same category as the dwelling or nesting house.

SUMMARY

Accurate estimating of muskrat populations is recognized as a basic requisite for intelligent management of marsh. The relative frequency of muskrat houses from year to year on an area, together with proper consideration given to the number of bank muskrats, offers a valid and practical index for such an estimate.

Means of distinguishing between "live" and "dead" houses are given together with rather complete descriptions of all types of structures involved and accompanying photographic illustrations. These include, nesting or dwelling houses, feeding huts or shelters, push-ups or breathers, bank leads and den burrows, and temporary and semi-permanent retreats. Muskrat "signs" are listed.

The various methods employed in making an annual census and their relative merits are briefly presented; transects, counts from roadside, ground strip counts and aerial census.

Normal range and movements, together with possible forced migration due to food depletion, deep-freezing or flooding have to be considered. Cyclic decline in the population due to disease, even after house construction in the fall, is a possibility that may upset estimates in some years.

During the fall and winter the parent muskrats and their last litter generally remain together for warmth in the same dwelling house until the spring mating season arrives. The number of muskrats per "live" dwelling house will therefore depend to a large extent on the average litter size of the particular race involved and the survival rate up to the time of the annual house count or fall survey.

A figure of 5 animals per large house has been more or less generally used during recent years as a basis for estimating muskrat populations. A more exact and satisfactory conversion factor could probably be derived if the survival rate were only known but data are almost completely lacking on this. Use of the average litter size of the race involved, in place of the more arbitrary figure of 5 is proposed for converting the number of "live" dwelling or nesting houses into population estimates.

As trapping in and immediately adjacent to muskrat houses is prohibited in some states, a proper understanding and interpretation of the general term "house" becomes a necessity. Making no distinction between the "feeding hut" and the large "dwelling or nesting house", and thereby placing them in the same category to the law enforcement officer, would make intelligent marsh management and proper harvesting of the annual fur crop extremely difficult under the frozen conditions in the more northern states.

LITERATURE CITED

ALDOUS, SHALER E.
1947. Muskrat trapping on Sand Lake National Wildlife Refuge, South Dakota. Jour. Wildlife Mangt. 11: 77-90.

ARTHUR, STANLEY C.
1931. The fur animals of Louisiana. Louisiana Dept. Conserv. Bul. 18 (revised).

BELL, W. B., et al.
1937. Methods in wildlife censuses. Jour. Amer. Statis. Assoc. 32: 537-542.

CARTWRIGHT, B. W.
1946. Muskrats, duck production, and marsh management. 11th North Amer. Conf. Trans., p. 454.

DOZIER, HERBERT L.
1937. Salinity as a factor in Atlantic coast tidewater muskrat production. 12th North Amer. Wildlife Conf. pp. 398-420, illus.

------ MARKLEY, MERLE H.; and LLEWELLYN, LEONARD M.
1948. Muskrat investigations on the Blackwater National Wildlife Refuge, Maryland, 1941-1945. Jour. Wildlife Mangt. (in press).

ERRINGTON, PAUL L.
1937. Habitat requirements of stream dwelling muskrats. Trans., 2d North Amer. Wildlife Conf. pp. 411-416.

1944. Additional studies on tagged young muskrats. Jour. Wildlife Mangt. 8: 300-306.

------ and ERRINGTON, CAROLYN STORM.
1937. Experimental tagging of young muskrats for purposes of study. Jour. Wildlife Mangt. 1: 49-61.

LAY, DANIEL W.
1945. Muskrat investigations in Texas. Jour. Wildlife Mangt. 9: 56-76.

SMITH, FRANK R.
1948. Muskrat investigations in Dorchester County, Maryland, 1930-34. U. S. Dept. Agr. Circ. 474, 24 pp.

STEARNS, LOUIS A.; MacCREARY, DONALD; and DAIGH, F. C.
1940. Effect of ditching for mosquito control on the muskrat population of a Delaware tidewater marsh. Univ. Delaware Agr. Expt. Sta. Bul. 225, 55 pp.

TAKOS, MICHAEL J.
1944. Summer movements of banded muskrats. Jour. Wildlife Mangt. 8: 307-311.

WARWICK, TOM.
1940. A contribution to the ecology of the muskrat in the British Isles. Zool. Soc. London Proc., Series A. Vol. 110, Pts. 3 and 4, pp. 165-201.